(1) that the evidence with respect to the European rainfall may be considered as "against a well-marked periodicity," and (2) that the result of a "systematic inquiry (by himself) into the American rain-returns altogether fails to establish the existence of a common cycle, so far as concerns the temperate zone." On each of these points I beg to make a few remarks.

The evidence on which Dr. Hunter bases his statement as to the European rainfall is derived (1) from an examination by Mr. Baxendell, for a short period, of the rainfall at *one* English station, (2) from an examination by the late Dr. Jelinek of *fourteen* stations on the Continent, from 1833 to 1869, and (3) from a comparison of the levels of the Elbe, Rhine, Oder, Danube, and Vistula, with the sun-spots for six cycles, a comparison which Dr. Hunter ascribes to Herr Gustav Wex, but which I believe is due to another.

Now, the evidence is much more extensive. Instead of being based on one British station and fourteen stations on the Continent, it is based on more than fifty British stations and more than forty stations on the Continent, and, taken with the evidence furnished by the rivers, it is, in my opinion, conclusive.

As to the American rainfall, an examination of thirty-four returns has given me much more favourable results than those Dr. Hunter has got from twenty-two stations, and I have little doubt that he will, as he extends his investigations, also find favourable results; but I think he must first adopt a method different from the one he used for Madras.

In support of my conclusion that the rainfalls of Europe and America are subject to a periodicity which closely corresponds with the sunspot periodicity, I will for the present only submit to your readers two tables, the one showing the general results for Great Britain, the Continent of Europe and America, and the other the results for one station in each of these countries, namely Edinburgh, Paris, and New Bedford.

TABLE II.—*Comparison of the Variation in the Sun-spot Area with the Variations in the Rainfalls of Great Britain, Continent of Europe, and America. from 1824 to 1867 inclusive.*

Years of Cycle.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Sun-spots	− 31·7	− 19·5	+ 3·5	+ 28·8	+ 39·5	+ 29·5	+ 10·4	− 4·9	− 14·8	− 21·2	− 19·4
Rainfall of Great Britain	− 2·22	− 1·67	+ 0·04	+ 1·16	+ 1·05	+ 1·46	+ 1·28	+ 0·89	+ 0·43	− 0·73	− 1·03
Rainfall of Continent of Europe	− 0·76	− 1·73	− 1·22	+ 0·44	+ 1·18	+ 0·97	+ 1·08	+ 0·60	− 0·45	− 0·36	+ 0·62
Rainfall of America...	− 2·73	− 0·88	+ 0·91	+ 0·53	+ 0·24	+ 1·34	+ 2·03	+ 0·84	− 0·27	− 0·66	− 1·24
Mean Rainfall Variation	− 1·90	− 1·43	− 0·09	+ 0·71	+ 0·82	+ 1·26	+ 1·46	+ 0·78	− 0·10	− 0·65	− 0·55

The above results have been obtained in the manner in which I obtained the rainfall variation in Table I. For Great Britain the number of stations is 54, for the Continent of Europe, 42, and for America, 32.

TABLE III.—*Comparison of Variation in Sun-spot Area with Variations in Rainfalls of Edinburgh, Paris, and New Bedford, from 1824 to 1867 inclusive.*

Years of Cycle.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Sun-spots	− 31·7	− 19·5	+ 3·5	+ 28·8	+ 39·5	+ 29·5	+ 10·4	− 4·9	− 14·8	− 21·2	− 19·4
Rainfall of Edinburgh	− 3·02	− 1·66	− 0·64	+ 2·50	+ 3·45	+ 2·86	+ 0·64	− 0·27	− 0·91	− 2·36	− 0·56
Rainfall of Paris ...	− 0·25	− 0·61	− 0·30	+ 1·27	+ 2·22	+ 1·90	+ 1·49	− 0·84	− 1·42	− 0·94	+ 0·48
Rainfall of New Bedford	− 3·07	− 1·03	− 0·69	− 0·32	− 0·19	+ 1·38	+ 3·47	+ 2·87	− 0·32	− 1·42	− 0·68
Mean Variation of Rainfall...	− 2·11	− 1·10	− 0·54	+ 1·15	+ 1·83	+ 3·05	+ 1·87	+ 0·59	− 0·88	− 1·57	− 0·25

It will be observed (see Table I.) that the variation in the Madras rainfall is not nearly so favourable as the variations for Edinburgh, Paris, and New Bedford.

What I have given here is but a small portion of the evidence in favour of a rainfall cycle. Having worked at the subject for six years, I have concluded that the whole evidence is as satisfactory as the evidence of a connection between sun-spots and terrestrial magnetism.

C. MELDRUM

Mauritius, February 1

JULIUS ROBERT VON MAYER

SEVERAL years ago (vol. v. p. 117) we published a paper by Prof. Tyndall on the nature and value of Mayer's researches, in which they were so fully detailed that now, on the occasion of the death of the man whose labours have won for him an undying renown, we need only briefly remind our readers of the chief events in his scientific career without entering into or attempting to renew a painful controversy of which it may be said that the truth lay neither wholly with one side nor the other.

Julius Robert Mayer was born at Heilbronn, November

25, 1814. In the neighbouring University of Tübingen, he underwent the usual course of studies in the medical faculty; and after obtaining his degree as physician, passed some time in the hospitals of Münich and Paris. His entrance into professional life was as ship's surgeon on an East India vessel. While thus engaged he made an observation apparently unconnected with, but really the origin of, all his subsequent investigations. To quote from Prof. Tyndall's paper referred to:—

"In the summer of 1840, he was at Java, and there observed that the venous blood of some of his patients had a singularly bright red colour. The observation riveted his attention; he reasoned upon it, and came to the conclusion that the brightness of the colour was due to the fact that a less amount of oxidation sufficed to keep up the temperature of the body in a hot climate than in a cold one. The darkness of the venous blood he regarded as the visible sign of the energy of the oxidation. It would be trivial to remark that accidents such as this, appealing to minds prepared for them, have often led to great discoveries. Mayer's attention was thereby drawn to the whole question of animal heat. . . ."

It was the idea thus suggested which he worked out to its issue in his great generalisation. In 1841 he returned from Batavia, and settled in his native town. Here he devoted the spare hours from his professional duties to the consideration of various unsolved physical problems. Although almost entirely isolated from scientific companionship, with next to no opportunity for experimental research, and limited in time, he evolved in a short period a succession of theoretical views, which in point of originality, boldness, and comprehensive grasp of facts, stand among the foremost in the history of physics. Mayer's first contribution to scientific literature—"Ueber die Kräfte der unbelebten Natur"—appeared in Liebig's *Annalen* in 1842, and contained within the space of eleven pages the forecast of the mechanical theory of heat, as accepted at present. At this time the caloric theory still found numerous advocates, despite the classic experiments of Rumford, of Davy, and of others; and but a small minority ventured to defend, from one standpoint or another, the idea of an intimate connection between heat and motion. It was reserved for Mayer to sum together the scattered facts, and to mould from them definite views on the nature of heat. With his introduction of the expression "the mechanical equivalent of heat," and the clear exposition of the mutual interchangeability of heat and mechanical energy, he dealt the last blow to the old theory, and thus largely helped to place on a firm foundation the new doctrines of the conservation and transformation of energy. But in this Mayer did not stand alone, nor was he the only one who had a firm hold of the conceptions which have been so fruitful of result. The quiet sap of experiment was going on side by side with these daring reconnaissances beyond the borders of the known and proved, and our own Joule, whose work does not suffer because he was not the sole worker and thinker in the field, was conducting those researches which have earned for him also an undying name and fame.

Three years elapsed before the appearance of Mayer's next work in 1845, on "Organic Movement in Connection with the Transformation of Matter." In this *brochure* of 100 pages, he details at greater length the new theory, and with a most extensive, varied, and novel series of illustrations from every branch of natural science and natural history, establishes the principles that all the so-called forces are interchangeable forms of energy—the one sole force—that energy is never created or destroyed, and that all natural phenomena are accompanied by a change of the form of energy. The logical consequences of the mechanical theory of heat were followed to their uttermost limits in Mayer's work "On Celestial Dynamics," in 1848. Here he seeks to solve the difficult problems of determining the thermal effects of the movements in the universe, the maintenance of the supply of solar heat, &c. One chief source of the latter he considers to be the heat evolved by the fall of innumerable meteorites &c., into the sun.

His "Remarks on the Mechanical Equivalent of Heat," in 1851, was his last notable contribution to the development of this subject. It possesses the same fulness of original ideas as its predecessors, and in point of vividness and clearness of conception and definition, can only be rivalled by Tyndall's "Heat as a Form of Motion." A collected edition of his writings, under the title of "Die Mechanik der Wärme," appeared at Stuttgart, 1867, and a second edition in 1874; this was followed by "Naturwissenschaftliche Vorträge" (Stuttgart, 1871), and two papers under the title of "Die Torricelli'sche Leere" and "Über Auslösung" (Stuttgart, 1876). The controversy on the priority of his discoveries led to disturbances in the mental health of the great *savant*, which, however, was in time completely restored. Dr. Mayer was of an original and witty turn of mind, unrestrained in a small company, but otherwise modestly retiring within himself.

In measuring the value of Mayer's scientific achievements it must not be forgotten that he published his theory at an epoch when physicists were directing their attention especially to this very subject, and that in Denmark and England the experiments were well advanced, which led to the complete establishment of our present knowledge of the character of heat and energy. It is, however, difficult to believe that any of his rivals in this province could have developed and amplified the theory in the masterly manner shown by this obscure German physician. In perusing his works, one scarcely knows which to admire most, the wonderful powers of classification and breadth of knowledge exhibited in every page, or the charming simplicity, clearness, and aptness of illustration with which abstruse theoretical questions are put within the comprehension of a tyro in science. Certainly in view of his life and surroundings, the contributions of Mayer to the progress of physics occupy a unique position in the history of science. To quote Dr. Tyndall again—

"Mayer grasped the mechanical theory of heat with commanding power, illustrating it and applying it in the most diverse domains. He began, as we have seen, with physical principles; he determined the numerical relation between heat and work; he revealed the source of the energies of the vegetable world, and showed the relationship of the heat of our fires to solar heat. He followed the energies which were potential in the vegetable up to their local exhaustion in the animal. But in 1845 a new thought was forced upon him by his calculations. He then for the first time drew attention to the astounding amount of heat generated by gravity where the force has sufficient distance to act through. He proved, as I have before stated, the heat of collision of a body falling from an infinite distance to the earth, to be sufficient to raise the temperature of a quantity of water equal to the falling body in weight 17,356° C. He also found in 1845 that the gravitating force between the earth and sun was competent to generate an amount of heat equal to that obtainable from the combustion of 6,000 times the weight of the earth of solid coal. With the quickness of genius he saw that we had here a power sufficient to produce the enormous temperature of the sun, and also to account for the primal molten condition of our own planet. Mayer shows the utter inadequacy of chemical forces, as we know them, to produce or maintain the solar temperature. He shows that were the sun a lump of coal, it would be utterly consumed in 5,000 years. He shows the difficulties attending the assumption that the sun is a cooling body; for supposing it to possess the high specific heat of water, its temperature would fall 15,000° in 5,000 years. He finally concludes that the light and heat of the sun are maintained by the constant impact of meteoric matter. I never ventured an opinion as to the accuracy of this theory; that is a question which may still have to be fought out. But I refer to it as an illustration of the force of genius with which Mayer followed the mechanical theory of heat through all its applications. Whether the meteoric theory be a matter of fact or not, with him abides the honour of proving to demonstration that the light and heat of suns and stars *may* be originated and maintained by the collisions of cold planetary matter."

His services were recognised by election to membership in the French Academy of Sciences and other foreign societies, and two years before his death the King of Würtemberg elevated him to the nobility. Mayer received the Copley Medal of the Royal Society in 1871.

OUR ASTRONOMICAL COLUMN

TOTAL SOLAR ECLIPSES.—The eclipse of the sun on July 29, in which the belt of totality traverses the North American continent from Behring's Strait to the Gulf of Mexico, is a return of the eclipse of June 16, 1806, which was observed in the United States by Bowditch and the well-known Spanish astronomer, Ferrer; in this year it was central, with the sun on the meridian in 65° 30′ W., and 42° 23′ N., and the duration of total eclipse exceeded five minutes. At its next return on June 27, 1824, it was total at apparent noon in 170° 4′ W., and 44° 42′ N., but the course of the central eclipse was almost entirely an ocean-track. In 1842, on July 8, the total phase passed over the south of Europe, and was observed by a great number of astronomers, amongst them by the Astronomer-Royal at the Superga, near Turin, and by Baily, at Pavia, and Arago, who was stationed at Perpignan, gave a graphic account of the circumstances attending the extinction of sunlight, which has been often quoted. At the ensuing return of the eclipse in 1860, the "Himalaya" expedition was organised, and numerous descriptions of the phenomenon are upon record; one of the best of them is that given before the Royal Society, as the Bakerian Lecture, by Mr. de la Rue. American observers will doubtless render good account of the eclipse in July next. Its last return in the present century will take place on August 9, 1896, when it will be total soon after sunrise in the north of Sweden and Norway, central at apparent noon in 112° 21′ E. and 65° 38′ N. between Nova Zemlia and the mainland of Asia, ending in 179° 3′ W. and 18° 35′ N. in the North Pacific.

We have already given in this column some particulars of the total phase as it will occur in the present year in the United States. The last total eclipse visible in that country took place on August 7, 1869, and is the subject of detailed description in a very interesting appendix to the *Washington Observations*. The line of totality in the eclipse of January 11, 1880, will just reach American ground before sunset; some fifty miles south of Monterey, in California, the eclipse will be total for about forty seconds, but the sun will be at less than 2° altitude, thus affording a similar case to that which some interpreters of Herodotus have supposed to have occurred in the eclipse of Thales at the site of the battle between the Medes and Lydians when "day was suddenly turned into night;" though of course a characteristic of every total eclipse, it does not frequently happen that after a long ocean track the total phase is just landed on the coast of a continent at sunset. But although January, 1880, will witness what is strictly the next total eclipse of the sun on the soil of the United States, it does not appear that there will be one favourably circumstanced for observation until the year 1923, on September 10. As it is possible some readers may be interested in seeing the particulars of this eclipse, in connection with the phenomenon in July next, or as the next following eclipse in which totality can be well observed in any part of the North American continent, we give elements, &c., here, derived upon a similar system of calculation to what has been applied to other eclipses in these columns.

G.M.T. of conjunction in R.A. 1923, Sept. 10, at 8h. 28m. 42s.

	°	′	″
Right Ascension	168	6	55·4
Moon's hourly motion in R.A. ...		34	53·8
Sun's ,, ,, ,, ...		2	14·9
Moon's declination	5	38	34·0 N.
Sun's ,, ...	5	6	14·5 N.
Moon's hourly motion in decl. ...		11	5·1 S.
Sun's ,, ,, ,, ...		0	56 8 S.
Moon's horizontal parallax		59	55·3
Sun's ,, ,, ...			8·8
Moon's semi-diameter		16	19·7
Sun's ,, ,, ...		15	53·7

Hence the central and total eclipse commences at 7h. 15·6m. in long. 154° 38′ E., lat. 48° 24′ N.; it falls with the sun on the meridian in 127° 54′ W., and 38° 5′ N., and ends at 10h. 15·7m. in 63° 25′ W., and 13° 50′ N. The following are also points upon the line of central eclipse:—

Long.	Lat.	Zen. Dist.	Long.	Lat.	Zen. Dist.
° ′	° ′	°	° ′	° ′	°
120 13 W.	... 34 0 N.	...31·1	106 12 W.	... 26 22 N.	...40·7
116 52	... 32 18	...33·1	94 33	... 20 55	...54·9
112 25	... 29 47	...34·7	81 14	... 16 41	...71·1

Calculating directly for the first of these positions which is near the N.W. point of the island of Santa Cruz, off the Californian Coast, we find

Totality begins at 0h. 46m. 22s. } Local mean times.
,, ends at 0h. 49m. 56s. }

The duration of the total eclipse on this coast will therefore be about 3½ minutes, with the sun at an altitude of nearly 60°.

GEOGRAPHICAL NOTES

CHINA.—Lieut. Gill, R.E., who, a short time back, arrived in British Burmah, after succeeding in traversing China from Shanghai to the Yünnan frontier, has furnished a Rangoon paper with an account of his journey. Lieut. Gill, in the first instance, proceeded, *viâ* Hankow, to Chung-king, in Szechuen, whence he made a trip to the northwards, visiting the fire-wells of Tsi-liu, at which place are also found brine-wells, from which good salt is made. Mr. Gill made his way to Sung-pao-ting, on the borders of the Koko Nor, and to Liang-ngan-foo, returning by a different route to Chêng-tu. Being joined by Mr. Mesney, the two began their long, perilous, and arduous journey to Burmah overland, in the course of which they passed Bathang, on the borders of Thibet, in about N. lat. 30°. Near Bathang ranges were crossed which were some 15,600 feet in height. The most common tree near Bathang is the pine, which in some places was seen in magnificent forests, and many of the trees were found to be about three feet in diameter.

A correspondent of the *North China Herald*, writing from Chefoo, says that a scheme is under consideration for working the coal-mines of the province of Shantung, which is well known to be rich in mineral wealth. Some 120 miles to the west of Chefoo there is a fine level plain, under which at no great depth is a bed of coal twenty feet thick. The natives have from time immemorial been digging holes and getting a little out here and there, but as they have no means of drainage, the pits have filled with water as soon as they reached the good coal. The Chinese Superintendent of Customs at Chefoo, has obtained permission to form a native company to carry out the work, with the aid of modern appliances. The scheme referred to is understood to include a tramway to the port of Chefoo. Another project on a larger scale has been formed under the auspices of